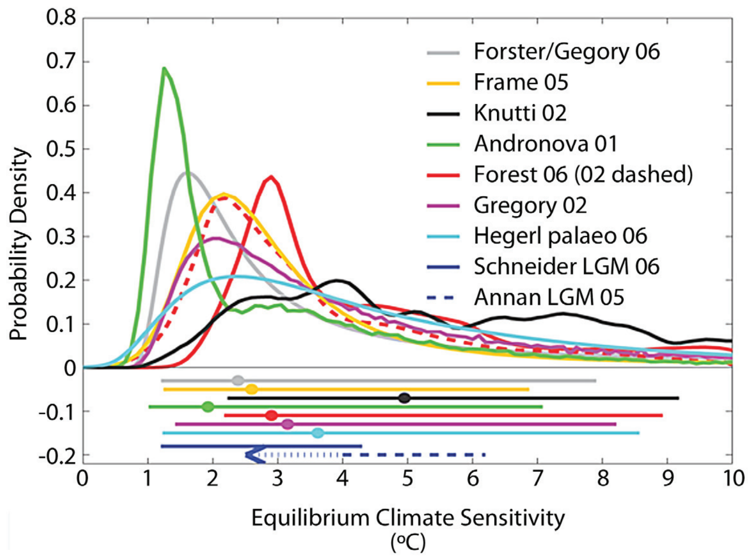
Climate Uncertainty and Implications for U.S. State-Level Risk Assessment Through 2050

Figure 1: Uncertainty in climate change due to a doubling of atmospheric CO_2. (Ref. 2). Shown here is the comparison between different estimates of the probability density (or relative likelihood) for climate sensitivity (i.e., temperature increase °C). All the probability curves have been scaled to integrate to unity between 0°C and 10°C sensitivity. The bars show the respective 5 to 95% ranges and the dots the median estimate.



Applying risk assessment and uncertainty quantification methods to climate change determines the avoidance value of mitigation and adaptation options.

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Although the existence of climate change is understood with a high degree of certainty, its extent and future dynamics remain highly uncertain. For example, the probability distributions of future global warming models (Figure 1), included in the 2007 Assessment Report from the United Nations' Intergovernmental Panel on Climate Changes (IPCC), are skewed heavily toward much larger temperature changes than the "best estimate" values commonly discussed for a doubling of CO_2 concentration in the atmosphere. The skewed probability distributions illustrate the uncertainty in future climatic conditions, which may be irreducible despite advances in climate science and the computational modeling of climate dynamics. Moreover, the large uncertainties create substantial risks if nothing is done to mitigate and/or prepare for climate change. Risk is the combination of potential consequences and the probability of those consequences occurring. Understanding the risks of climate change is useful for policymakers to prioritize any actions that could avoid the realization of those risks. As shown here, the potentially realized higher temperature and adverse precipitation conditions implied by the climate change probability distribution pose disparate consequences for the states across the country.

The extensive systems integration capabilities at Sandia have been used by researchers to generate the first truly integrated assessment of climate risk among the contiguous 48 states. Multiple departments combined their expertise in uncertainty quantification, risk assessment, climate science, hydrology, infrastructure impacts, and macroeconomic analysis to develop a state-level risk assessment of climate change impacts through the year 2050. The most uncertain impact of the predicted climate change characteristic, *precipitation*, was used to assess economic impacts associated with water availability. Changes in water availability can have clear,

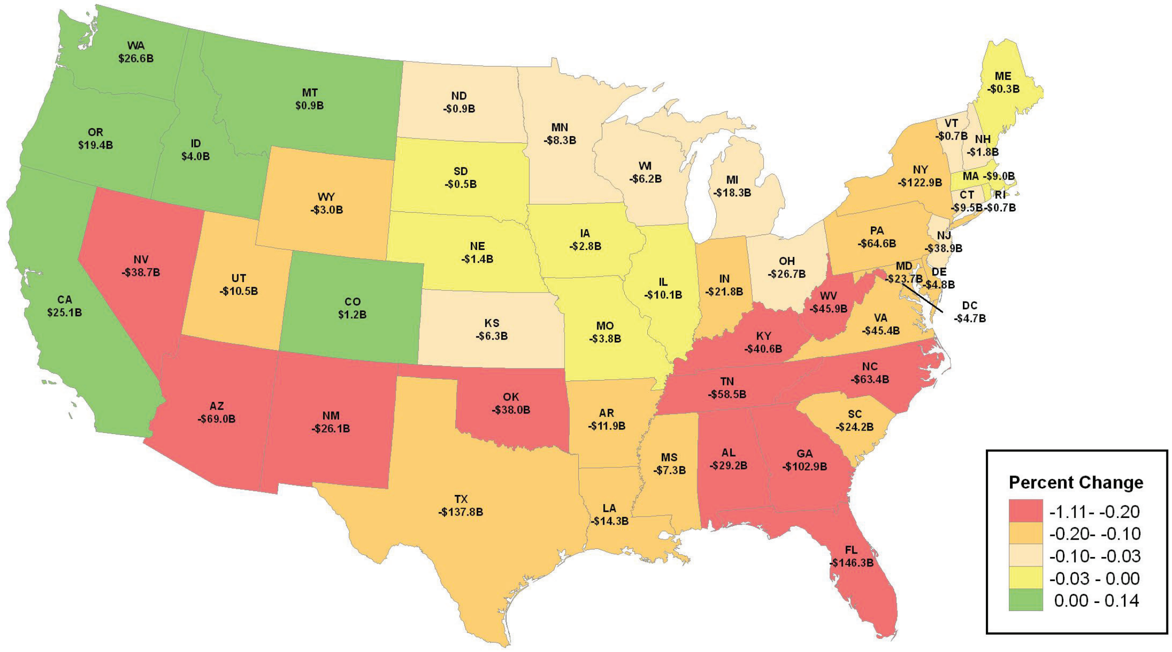

Figure 2: State-level economic impacts of climate change from 2010 through 2050, due to a doubling of CO_2 and the consequent changes in water availability. The colors represent various amounts of change in the economic activity (gross state products) of each state.

direct socioeconomic consequences; the summary risk is the integral of the consequence of reduced precipitation over the entire probability distribution of those precipitation conditions. Researchers then determined the implied hydrologic conditions using the Sandia Energy-Water model, followed by a determination of the economic impacts across interacting state-level economics, over time, for 70 industries using the macroeconomic analysis capabilities of Sandia's National Infrastructure Simulation and Analysis Center. Finally they combined the time-dependent, probabilistic, consequences to determine the risk for each for the 48 contiguous states.

At the national level, the risk between 2010 and 2050 is estimated to be $1.2 trillion, with an employment loss of nearly seven million labor years. All states except the Pacific Northwest, California and Colorado show net negative impacts over the time period. The benefits to the Northwest may be overestimated due to the lack of intra-annual resolution on precipitation affecting snow cover within the analysis. Conversely, while California and Colorado do suffer the negative impacts from the loss of precipitation often noted in previous studies, worse conditions in surrounding states cause population in-migration that lead to a net benefit in California and Colorado economic conditions. In addition to the risk assessment and level of detail, this dynamic interaction among the states is a critical element that is missing from previously published studies of climate change impacts.

Figure 2 summarizes the state-level impacts of climate change on Gross State Product (GSP) from 2010 through 2050 in billions of 2008 dollars. Because Sandia is using the vantage point of the population experiencing the loss, the risk in cost terms is the actual value calculated rather than a discounted value. Any effort to mitigate the risk by actions today would consider the non-zero discount rates that reflect the time preference society uses to compare conditions today to future conditions.

References

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